EFFECTS OF INTENSIVE FOREST MANAGEMENT ON NON-UNGULATE MAMMALS OF VANCOUVER ISLAND

PROBLEM ANALYSIS

INTEGRATED WILDLIFE INTENSIVE FORESTRY RESEARCH

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EFFECTS OF INTENSIVE FOREST MANAGEMENT ON NON-UNGULATE MAMMALS OF VANCOUVER ISLAND

Problem Analysis

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PREFACE

This publication is one of three companion publications resulting from the problem analysis on "The effects of intensive forest management on non-ungulate wildlife of Vancouver Island". Non-ungulate species include all amphibian, reptile, bird, and mammal (excluding deer and elk) species that occur on Vancouver Island.

Several factors, in conjunction with the demands imposed by an increase in public awareness, are responsible for the initial problem analysis proposal. First, while management efforts on Vancouver Island will certainly continue to focus on deer and elk, interest is increasing in other game and nongame species. Second, experience elsewhere indicates that, with the increased concern for the welfare of these species, the demand for their greater protection and management will also increase. Third, it is likely that intensive forest management will affect these species at least as significantly as it has affected deer and elk. Finally, our knowledge of the habitat requirements of these species is very limited.

What is known, though, is that timber harvesting is the major factor affecting species habitats on Vancouver Island. Begun over a century ago, logging has since altered a major portion of the forested land on Vancouver Island. Because the Island has one of the most productive timber producing areas in the province, timber harvesting and its associated intensive forestry practices will certainly continue to play a major role in altering species habitats.

Wildlife management is the responsibility of the Fish and Wildlife Branch (British Columbia Ministry of Environment); the land base on which the wildlife live is primarily under the control of the Ministry of Forests.

The goals of wildlife management in British Columbia are:

1. to maintain the diversity of species representative of the major biophysical zones of the province; and
2. to ensure that within the constraints of land capability and biological limits of each species, wildlife is available in sufficient abundance to meet the recreational and economic needs of society.

To meet these goals, objectives, policies and management prescriptions have been developed and are presented in a series of draft management documents prepared by the Branch.

The Ministry of Forests Act dictates that the Ministry is responsible for planning "...the use of the forest and range resources of the Crown so that the production of timber and forage; the harvesting of timber; the grazing of livestock; and the realization of fisheries, wildlife, water, outdoor recreation and other natural resource values are coordinated and integrated, in consultation and cooperation with other ministries and agencies of the Crown and with the private sector" (Ministry of Forests Act 1978, Section 4c).

Implementation of these two ministerial mandates is the guiding force influencing the interactive management of forests and wildlife.

The OBJECTIVE of this problem analysis is:

> TO IDENTIFY RESEARCH QUESTIONS AND PRIORITIES REGARDING THE HABITAT REQUIREMENTS AND THE EFFECTS OF INTENSIVE FOREST MANAGEMENT ON THE NON-UNGULATE WILDLIFE OF VANCOUVER ISLAND.

To facilitate the large number of non-ungulate species to be considered in this analysis, species were grouped under three general taxonomic headings: 1) amphibians and reptiles; 2) mammals; and 3) birds. A total of 195 non-ungulate species were considered. Within each group, species were further organized by lifeforms -- an assemblage of species with similar reproductive and feeding strategies (Niemi and Pfanmuller 1979). Organizing species into lifeforms was designed to assist identification of the habitat requirements and effects of intensive forest management common to all, or a majority, of the species in the lifeform. Information on each of the three species groups was compiled, organized and analysed separately. Although this resulted in some differences in format, the topics addressed were the same. These topics include: the problem; wildlife management objectives and policies; species distribution, status, protection, numbers, and habitat requirements; and effects of intensive forest management. Research recommendations, designed to address the information needs identified, conclude each analysis.

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TABLE OF CONTENTS

PREFACE iii
ACKNOWLEDGEMENTS v

1 INTRODUCTION 1

2 PROBLEM 1

3 MANAGEMENT OBJECTIVES AND POLICIES 3

4 STATUS 3

5 DISTRIBUTION 6

6 HABITAT REQUIREMENTS 11
6.1 Shrews 11
6.2 Bats 12
6.3 Vancouver Island Marmot 14
6.4 Red Squirrel 15
6.5 American Beaver 16
6.6 Deer Mouse 16
6.7 Townsend's Vole 16
6.8 Wolf 17
6.9 American Black Bear 17
6.10 Raccoon 18
6.11 American Marten 18
6.12 Ermine 20
6.13 American Mink and River Otter 21
6.14 Wolverine 21
6.15 Cougar 22

7 EFFECTS OF INTENSIVE FOREST MANAGEMENT 23
7.1 Vagrant Shrew, Dusky Shrew, Deer Mouse and Townsend's Vole 23
7.2 Bats 25
7.3 Vancouver Island Marmot 26
7.4 Red Squirrel 27
7.5 American Mink, River Otter, American Beaver and American Water Shrew 27
7.6 Wolf 28
7.7 American Black Bear..... 28
7.8 Raccoon 29
7.9 American Marten..... 29
7.10 Ermine 30
7.11 Wolverine 31
7.12 Cougar 31

8 EFFECT OF NON-UNGULATE MAMMALS ON REFORESTATION 31
8.1 Costs 32
8.2 Benefits 33

9 RESEARCH RECOMMENDATIONS 33

10 SPECIES PRIORITY 37

11 SUMMARY 39

12 REFERENCES 40

13 APPENDICES 48

LIST OF TABLES

1	Management problems	2
2	Management objectives	4
3	Management policies	5
4	Status of indigenous non-ungulate mammals of Vancouver Island	7
5	Distribution of indigenous non-ungulate mammals of Vancouver Island by region and biogeoclimatic subzone	8
6	Distribution of indigenous non-ungulate mammals of Vancouver Island	9
7	Distribution of introduced non-ungulate mammals of Vancouver Island	10
8	Species priority rating list	38

1 INTRODUCTION

Many of the mammal species occurring on the British Columbia mainland are not present on Vancouver Island (Carl 1947). Of the 126 species known to inhabit the province (Cowan and Guiguet 1978), only 29 terrestrial mammals are indigenous to Vancouver Island. Of these, 27 are non-ungulate mammals. In addition, eight introduced species are known to occur on the Island. Terrestrial, non-ungulate mammals of Vancouver Island are listed in Appendix 13.1 (Banfield 1977, Cowan and Guiguet 1978).

The scope of this problem analysis includes only terrestrial non-ungulate mammals. Marine mammals, although perceived to be affected by intensive forest practices, will not be discussed. However, in view of the current killer whale-logging controversy in the Robson Bight area, a similar problem analysis on marine mammals, either as a group or separately, is warranted in the future.

The emphasis of this problem analysis is on indigenous species of Vancouver Island; introduced species will be discussed only in terms of their Island distribution.

2 PROBLEM

Vancouver Island's mammals have been of concern to wildlife biologists and forest managers for many years. The species that have received the most attention are those having the greatest economic (e.g. furbearers) and sports hunting (e.g. big game) value. The major wildlife management problems for non-ungulate species on Vancouver Island are presented in Table 1. These have been identified by the Fish and Wildlife Branch and are described in its Preliminary Wildlife Plans (B.C. Ministry of Environment 1979a-d, 1980a-c). Lack of inventory, lack of habitat requirement information, and the destruction of their habitat (or that of their prey) are problems common to many of Vancouver Island's mammal species. That Table 1 is incomplete exemplifies another problem: non-ungulates are a low priority and consequently little information is available for their management.

TABLE 1. Management problems

	Inventory Incomplete or Lacking	Habitat Destruction	Habitat Requirements Not Identified	Predator Relationships Unclear	Limited Research Available	Public/ Management Conflict	Animal/ Human Conflict	Cause Damage	Difficult to Control	Under Harvested[1]
Vancouver Island Marmot	X	X	X		X					
Red Squirrel								X[2]		X[3]
American Beaver	X							X		X
Wolf	X			X		X	X	X	X	X
American Black Bear	X				X	X	X	X		X
Raccoon								X		
American Marten	X	X	X							
American Mink	X	X	X							
Wolverine	X	X	X							
River Otter	X	X	X							
Cougar	X				X		X	X		

[1] under harvested is defined as not using the sum of the available surplus or portion of the surplus after natural mortality (Saunders per. comm.)
[2] reforestation problem
[3] Saunders (pers. comm.)

Compiled from Preliminary Wildlife Plans (B.C. Ministry of Environment 1979a-d and 1980a-c) and Vancouver Island Marmot 5-Year Plan (Hebert 1981).

The forest industry's primary concern is timber production, and mammals can have important impacts on timber growth and yield. Although research in this area has been aimed at developing methods for species extirpation rather than maintenance, it has provided information on some species not currently investigated by the Fish and Wildlife Branch.

The conflict between wildlife management and forest management has had its highest profile whenever mammal species have been of concern. The general lack of information concerning habitat requirements of these species and the effects of intensive forest management practices on their habitat continue to perpetuate the conflict. In order to provide forest managers with the necessary information and/or guidelines so that wildlife managers can maintain mammal species, information on species distributions, habitat requirements, and the effects of forest practices on both are required immediately.

3 MANAGEMENT OBJECTIVES AND POLICIES

Management plans have been developed for some of the non-ungulate mammal species that occur on Vancouver Island. The objectives and policies for these non-ungulate species, as described in the species Preliminary Wildlife Plans (B.C. Ministry of Environment 1979a-d, 1980a-c), are summarized in Tables 2 and 3, respectively. Management policies address three general topics: habitat protection, species inventories, and public education. Research is also encouraged but because of the number of species and lack of funds, educational institutions and interested agencies are the major sources of this information.

4 STATUS

Most mammals are protected under the jurisdiction of the current Wildlife Act (1979). Under this act, nine of Vancouver Island's mammal species are designated as furbearers and three as big game. Currently, the Vancouver Island marmot (Marmota vancouverensis) is the only Vancouver Island species on the provincial threatened and endangered species list and bears the endangered designation (B.C. Ministry of Environment 1979b). According to recent surveys, however, this designation has been questioned and it has been

TABLE 2. Management objectives

	Maintain Population	Permit Harvest: # unspecified	Permit Harvest: # specified	Control Problem Animals	Public Viewing
Vancouver Island Marmot	X				
Red Squirrel	X	X			
American Beaver	X	X			X
Wolf	X	X		X	
American Black Bear	X		X	X	X
Raccoon	X	X		X	
American Marten	X	X			
American Mink	X	X			
Wolverine	X	X			
River Otter	X	X			
Cougar	X			X	

Compiled from Preliminary Wildlife Plans (B.C. Ministry of Environment 1979a-d and 1980a-c) and Vancouver Island Marmot 5-Year Plan (Hebert 1981)

TABLE 3. Management policies

	Maintain Species Habitat	Protect Critical Habitat	Designate Protected Areas	Establish Inventories	Encourage Harvesting	Set & Monitor Harvest Levels	Public Education	Provide Public Viewing Areas	Trapper Education	Species Control (Problem animals)	Encourage Research
Vancouver Island Marmot	X	X	X	X			X				
Red Squirrel				X							
American Beaver						X	X	X	X		
Wolf	X		X				X			X	
American Black Bear			X		X		X	X		X	X
Raccoon				X			X				
American Marten		X		X		X			X		
American Mink				X		X			X		
Wolverine		X		X		X			X		
River Otter				X		X			X		
Cougar	X		X				X			X	

Compiled from Preliminary Wildlife Plans (B.C. Ministry of Environment 1979a-d and 1980a-c) and Vancouver Island Marmot 5-Year Plan (Hebert 1981)

suggested that this species be reclassified as rare (Smith 1982). In previous years, the Vancouver Island wolf (Canis lupus crassodon) was designated threatened, but an increase in the population has necessitated a change of this status. It has also recently been proposed that the wolverine be entered on the federal endangered species list (Moore 1980). Munroe and Hebert (pers. comm.) suggest that British Columbia's population does not warrant the designation. However, the status of Vancouver Island's populaton is unclear. The most recent recorded wolverine sighting on the Island was a road kill in 1978. Table 4 summarizes the status, abundance, number of subspecies, and the subspecies' occurrence on the British Columbia mainland.

5 DISTRIBUTION

Species distribution information is limited. Inventories of most non-ungulate species and for many areas of Vancouver Island are unavailable. Some reasons include: 1) low priority for inventory, 2) sightings are not reported, 3) difficulty of observing some species, and 4) unavailable funding. The sources used to provide the information on species distribution include: Mammals of Canada (Banfield 1977), The Mammals of British Columbia (Cowan and Guiguet 1978), species Preliminary Management Plans (B.C. Ministry of Environment 1979a-d, 1980a-c); sighting records (British Columbia Wildlife Record Scheme, Zoology Division, British Columbia Provincial Museum); and published papers (including Swath 1912, Campbell 1972, Tatum 1972, Dawe 1980, and others).

This species distribution information for indigenous species was matched to the biogeoclimatic subzones (Packee 1975, Klinka et al. 1979) within defined regions of Vancouver Island as described by Ellis (1980) (Table 5). Table 6 summarizes this information into the three Biogeoclimatic Zones of Vancouver Island and also gives a description of their geographic distribution. Table 7 outlines the distribution of Vancouver Island's eight introduced species.

Most of this information is, however, presented in a generalized form and does not provide a clear indication of actual species distribution. Therefore, to present a better indication of where species occur, as well as to

TABLE 4. Status of indigenous non-ungulate mammals of Vancouver Island

Species	Lifeform	Abundance			Speciation[7]	
		Van Is[5]	B.C.[5]	Stability[6]	# Subspecies on Van Is	Occurrence on Mainland
Vagrant Shrew	6	c	c		1	No
Dusky Shrew	6	c	c		1	No
American Water Shrew	7	c	c		1	No
Little Brown Bat	5	u	u		1	Yes
Yuma Bat	5	u	u		1	Yes
Keen's Bat	5	u	u		1	Yes
Long-eared Bat	5	u	u		1	Yes
Long-legged Bat	5	u	u		1	Yes
California Bat	5	u	u		1	Yes
Silver-haired Bat	5	u	u		1	Yes
Townsend's Big-eared Bat	1	u	u		1	Yes
Big Brown Bat	5	u	u		1	Yes
Hoary Bat	4	u	u		1	Yes
Vancouver Island Marmot[1]	6	50-100	50-100	Increase	1 (species)	No
Red Squirrel[2]	3	c	u		1	Yes
American Beaver[2]	7	12 000-18 000	400 000-600 000	Decrease	1	Yes
Deer Mouse	6	c	u		2	No
Townsend's Vole	6	c	u		2	No
Wolf[2,3]	5	440[4]	6300	Increase	1	No
American Black Bear[3]	5	7000	62 800	Stable	1	No
Raccoon[2]	5	c	27 500-41 250	Increase	1	No
American Marten[2]	5	4500-6000	150 000-200 000	Decrease	1	Yes
Ermine[2]	6	u	350 000-750 000	Increase	1	No
American Mink[2]	7	6000-12 000	50 000-100 000	Stable	1	No
Wolverine[2]	2	50-800	5000-8000	Increase	1	No
River Otter[2]	7	2850-5700	15 000-30 000	Stable	1	Yes
Cougar[3]	5	1000-1200	3230	Stable	1	No

c - common
u - numbers unknown
1 - endangered status (B.C. Ministry of Environment 1979b)
2 - designated as a furbearer (Wildlife Act 1979)
3 - designated as a big game (Wildlife Act 1979)
4 - includes part of mainland
5 - population numbers were compiled from Preliminary Management Plans (B.C. Ministry of Environment 1979a-d, 1980a-c)
6 - from Threatened and Endangered Species Status (Gwilliam 1980)
7 - from Threatened and Endangered Species Status (Gwilliam 1980) and Mammals of British Columbia (Cowan and Guiguet 1978)
8 - B. Smith (pers. comm.)

TABLE 5. Distribution of indigenous non-ungulate mammals of Vancouver Island by region and biogeoclimatic subzone

Species	ALBERNI INLET-QUALICUM TO SOUTH					ALBERNI-QUALICUM TO MUCHALAT INLET-CAMPBELL R					MUCHALAT INLET-CAMPBELL R TO QUATSINO SND-PT McNEILL					QUATSINO SND-PT McNEILL TO NORTH				
	Douglas-fir		Western Hem		Mtn Hem[1]	Douglas-fir		Western Hem		Mtn Hem	Douglas-fir		Western Hem		Mtn Hem	Douglas-fir[1]		Western Hem		Mtn Hem[1]
	Dry	Wet	Dry	Wet		Dry[1]	Wet	Dry	Wet		Dry[1]	Wet	Dry	Wet		Dry	Wet	Dry[1]	Wet	
Dusky Shrew			x	x			x	x	x	x		x	x	x	x				x	
Vagrant Shrew	x	x	x				x	x	x	x		x	x							
American Water Shrew	x	x	x	x			x	x	x	x		x	x	x	x				x	
Little Brown Bat	x								x											
Yuma Bat	x											x		x						
Keen's Bat	x								x										x	
Long-eared Bat	x						x													
Long-legged Bat							x													
California Bat	x						x					x							x	
Silver-haired Bat	x																			
Townsend's Big-eared Bat	x		x				x	x												
Big Brown Bat	x																			
Hoary Bat	x																			
Vancouver Island Marmot										x										
Red Squirrel	x	x	x	x			x	x	x	x		x	x	x	x				x	
American Beaver	x	x	x	x			x	x	x	x		x	x	x	x				x	
Deer Mouse	x	x	x	x			x	x	x	x		x	x	x	x				x	
Townsend's Vole	x	x	x	x			x	x	x	x		x	x	x	x				x	
Wolf	x	x	x	x			x	x	x	x		x	x	x	x				x	
American Black Bear	x	x	x	x			x	x	x	x		x	x	x	x				x	
Raccoon	x	x	x	x			x	x	x			x	x	x					x	
American Marten	x	x	x	x			x	x	x	x		x			x				x	
Ermine	x	x	x				x		x				x	x					x	
American Mink	x	x	x	x			x	x	x			x		x					x	
Wolverine		x	x	x			x	x	x	x				x	x					
River Otter	x	x	x	x			x	x	x	x				x	x				x	
Cougar	x	x	x	x			x	x	x	x		x		x					x	

[1] subzones or zones not found within the defined geographic region of Vancouver Island

TABLE 6. Distribution of indigenous non-ungulate mammals of Vancouver Island

Species	Douglas-fir Dry	Douglas-fir Wet	Western Hemlock Dry	Western Hemlock Wet	Mtn Hemlock	Geographic Extent
Dusky Shrew	x	x	x	x	x	throughout Van Is; least abundant in Dry Douglas-fir Subzone
Vagrant Shrew	x	x	x	x	x	south of Sayward, particularly on east coast in Dry Douglas-fir Subzone
American Water Shrew	x	x	x	x	x	throughout Van Is
Little Brown Bat	x			x		throughout Van Is
Yuma Bat	x			x		throughout Van Is
Keen's Bat	x	x		x		coastal areas
Long-eared Bat	x			x		throughout Van Is
Long-legged Bat	x					rare; only specimen from Miracle Beach Provincial Park
California Bat	x	x		x		throughout Van Is
Silver-haired Bat	x					eastern tip, Nanaimo to Victoria
Townsend's Big-eared Bat	x	x	x			east side, Miracle Beach south
Big Brown Bat	x					east side, Miracle Beach south
Hoary Bat	x					only record - Victoria
Vancouver Island Marmot				x	x	core area; alpine areas between Green Mountain and Butler Mountain
Red Squirrel	x	x	x	x	x	throughout Van Is
American Beaver	x	x	x	x	x	throughout Van Is
Deer Mouse	x	x	x	x	x	throughout Van Is
Townsend's Vole	x	x	x	x	x	throughout Van Is
Wolf	x	x	x	x	x	throughout Van Is
American Black Bear	x	x	x	x	x	throughout Van Is
Raccoon	x	x	x	x	x	throughout Van Is
American Marten	x	x	x	x	x	throughout Van Is
Ermine	x	x	x	x	x	throughout Van Is
American Mink	x	x	x	x		throughout Van Is
Wolverine		x	x	x	x	throughout Van Is
River Otter	x	x	x	x	x	throughout Van Is
Cougar	x	x	x	x	x	throughout Van Is

TABLE 7. Distribution of introduced non-ungulate mammals of Vancouver Island

Species	Introduced	Geographical Extent	Current Status
Eastern Cottontail	1965 from VanDermeer's Game Farm	southeastern side as far as Nanaimo	expanding
European Rabbit	escaped from farm	Sooke Road area; Highland district	small localized populations
Grey Squirrel	1966 from VanDermeer's Game Farm	southern tip	expanding?
Muskrat	1923	throughout Van Is	stable
Roof Rat	with human settlement	?	stable
Norway Rat	with human settlement	?	stable
House Mouse	with human settlement	?	stable
Nutria	escaped from fur farm	Cowichan River, Courtenay	?

draw attention to those species with few sighting records, the information from the above sources has been combined with other known species information (e.g. habitat preferences). For example, although actual sighting records for the American water shrew (Sorex palustris) are not available for all areas of Vancouver Island, its preferred habitat would enable it to occur almost anywhere on the Island. In contrast, the little brown bat (Myotis lucifugus) reportedly occurs throughout Vancouver Island (Cowan and Guiguet 1978), but because of the few recorded sightings and the little that is known about this bat species, its occurrence throughout the Island is questioned. Although bias is inherent in the process, this approach was taken to provide an interpretive representation of species distribution as well as to identify information disparities. This is discussed in sections 6 and 7.

6 HABITAT REQUIREMENTS

Information on species habitat requirements is essential for wildlife management. However, research has generally been directed at the high priority ungulate and game species, and on Vancouver Island few studies have been conducted on non-ungulate mammals. The majority of information presented here is based on studies conducted in coniferous forests on the Mainland.

Habitat requirements discussed are known or hypothesized and are based on the life history information (Appendix 13.3) and species use of habitat components (Appendix 13.4) and succession stages (Appendix 13.5).

6.1 Shrews

The generally damp climate of Vancouver Island allows for the widespread occurrence of vagrant (Sorex vagrans) and dusky (Sorex obscurus) shrews. Damp surface litter is a key habitat requirement and wherever this occurs these shrew species will usually be found. The habitats favoured are forests with their characteristic accummulation of humus, litter and ground debris. This habitat provides protective shelter, a substrate for their tunnelling systems, and the habitat of their invertebrate prey (insects, grubs, earthworms). The vagrant shrew prefers a drier situation

than the dusky shrew and is more common in the damp areas of the Coastal Douglas-fir Biogeoclimatic Zone; the dusky shrew is more common in the Coastal Western Hemlock Biogeoclimatic Zone (Harestad pers. comm.).

The American water shrew (Sorex palustris), in contrast, occurs in a rather limited habitat. They are found in riparian habitat along the banks of fast, free-flowing cold mountainous streams. They are generally found at high elevations (900-2200 m) where this habitat is abundant, but they are also known to occur at lower elevations (100 m) when habitat is available (Conway 1952). The American water shrew prefers streams in dense coniferous climax forests where overhanging or mossy banks, rocks and logs provide the required hunting cover (Banfield 1977).

6.2 Bats

Many of Vancouver Island's bat species are known to occur in habitats associated with water (Barbour and Davis 1969). Water provides an open foraging site for these aerial feeding insectivores and is an important component in their habitat. The water-habitat association of some species is known. The yuma bat (Myotis yumanensis), believed to be the North American bat most closely associated with water, prefers open areas adjacent to water bodies rather than forested areas. The little brown bat (Myotis lucifugus), long-legged bat (Myotis volans), silver-haired bat (Lasionycteris noctivagans), and Keen's bat (Myotis keenii) prefer forest habitats associated with water. The long-eared bat (Myotis evotis), California bat (Myotis californicus), Townsend's big-eared bat (Plecotus townsendii), big brown bat (Eptesicus fuscus), and hoary bat (Lasiurus cinereus)) have not been reported as requiring water-associated habitat; but, information is limited and this may be required.

Bats are nocturnal and require day and nighttime roosts. These roosting sites are usually sexually segregated: females and their young roost together in maternity colonies (called nursery sites), while males roost elsewhere either singly or in small groups. Many species also prefer different sites for their day and nighttime retreats. This behaviour is probably limited to males since females must return to the colony and

provide for the needs of their young. A variety of roosting and nursery sites are used, including: 1) snags, under bark or in cavities; 2) branches or foliage of trees; 3) caves; 4) crevices; and 5) man-made structures, such as buildings, bridges, or mines (Barbour and Davis 1969, Banfield 1977, Cowan and Guiguet 1978). All but two of Vancouver Island's bat species prefer natural or excavated cavities as roosting sites. The hoary bat is thought to require tree foliage; the Townsend's big-eared bat, caves. Roosting sites are an important component of the habitat and are possibly the factor limiting species habitat selection. For example, Barbour and Davis (1969) found that in habitat apparently suitable for the yuma bat, none were present. They suggested that a lack of daytime roosts was probably the primary cause. Some species however have been observed using only man-made structures and this reflects their adaptability to urbanization. Species preferences are included in Appendix 13.3.

Bats cope with cold winter temperatures by either hibernating or migrating. Although information concerning the winter habits of Vancouver Island's native species is lacking, most species are believed to migrate south into the United States in search of suitable hibernacula. Three species have, however, been reported hibernating on Vancouver Island. The silver-haired bat and the big brown bat have been recorded hibernating in the Victoria area (Carl 1945, Tatum 1972); the California bat was reported overwintering on the Marshall-Steveson Wildlife Unit at Qualicum Beach, B.C. (Dawe 1980). The big brown bat is also known to hibernate as far north as Prince George, and the long-eared bat and the little brown bat as far north as Williams Lake (Jobin 1952). They are, therefore, undoubtedly capable of occurring at this latitude (i.e. Vancouver Island) during winter. Cowan (1942) suggests that the long-legged bat and yuma bat may also hibernate at this latitude.

Many species are interspecific colonial hibernators. Within the hibernacula, species segration does occur, however, and is a reflection of their temperature and humidity requirements. For example, the Townsend's big-eared bat and the big brown bat are hardy species and can tolerate cold temperatures from -2°C to +12°C and 0°C to +18°C, respectively. Because

the big brown bat cannot tolerate a cool, moist environment, it requires the area near the opening of the hibernacula where the relative humidity (RH) does not go above 80%. The little brown bat also prefers a dry environment (less than 80% RH), but cannot tolerate temperatures less than 4°C. Keen's bat prefers temperatures cooler than those suitable for the little brown bat but with a relative humidity of 97%. Although hibernacula temperature and relative humidity requirements are not known for some bat species, temperatures consistently above 0°C are probably required. For most species, caves, mines and buildings provide suitable hibernacula. The silver-haired bat and hoary bat are exceptions, requiring trees instead.

6.3 Vancouver Island Marmot

Vancouver Island marmot (Marmota vancouverensis) colonies are typically found in the subalpine areas of Vancouver Island (Heard 1977, Carson 1978). They live in habitat characterized by south-facing forb meadow in association with a steep cliff or talus slope above. This topography provides the longest summer period possible thus enabling them to withstand the rigors of high elevation winters. The cliffs and ledges are required for lookout sites and early summer feeding areas while the lush meadows provide food throughout the summer. During their very short annual activity period (4-5 months), marmots must assimilate enough food to sustain them throughout their long hibernation (7-8 months)(Heard 1977). Each colony is considered a discrete population and it has been suggested that any disturbance which disrupts their feeding is potentially detrimental to the colony (Heard 1977). Boulders to burrow beneath or rocky ground to burrow in is required to provide resting and winter hibernacula.

Interest in the Vancouver Island marmot is recent. Because this species is endemic to British Columbia and Canada, and currently classified as an endangered species (less than 100), it is important that a clear understanding of their habitat requirements be known to ensure their continued occurrence. Recently initiated, yearly inventories are providing much-needed information on distribution and population numbers and it is

extremely important that they continue. Still required, however, is information on what habitat or which habitat components are necessary for species dispersal.

6.4 Red Squirrel

Although the red squirrel (Tamiasciurus hudsonicus) occurs in a variety of habitats, the presence of seed-bearing conifers is required. Coniferous seeds are the species' major food item and the mainstay of its diet. Throughout the winter, cone caches in tree cavities or in underground digs are used (Hatt 1929). Other food items consumed include deciduous nuts and seeds, tree buds, epigeous and hypogeous fungi, and some berries and herbs. These vary seasonally and with the local vegetation species available. Individual food preferences have also been observed among squirrels living in similar habitats in adjacent regions (Hatt 1929).

Hatt (1929:40) states that, "In local distribution, habitat preference depends much on food supply, but the suitability of nest sites .... play the major role." Three nest site locations are used: 1) tree cavities; 2) tree limbs; and 3) underground burrows (Hatt 1929, Fancy 1980). The nest location depends upon what is available, but tree cavity nest sites are preferred. Abandoned woodpecker or flicker cavities are commonly used. In areas where cavities are unavailable, outside nests on tree limbs or underground are constructed. Fancy (1980) found that the most important factors influencing nest-tree selection in the boreal forest near Atlin, B.C. were tree diameter and branching structure. He also found that 90% of the nest trees (white spruce) comprised only 41% of the coniferous basal area in the study site, and suggests that some tree species are more suitable and consequently preferred. Hatt (1929) reports that the tree species used for food and shelter can differ within the squirrel's home range. Ground nests are commonly dug beneatn stumps and consist of a network of tunnels connecting breeding and resting nests with food caches. On Vancouver Island, underground systems are extensively used, especially in second-growth forests where the absence of tree cavities in these stands is suggested as the probable cause (Nyberg pers. comm.).

6.5 American Beaver

Food and water are the two components that determine a beaver's (Castor canadensis) habitat. An inhabitant of fresh-water, the beaver requires a seasonably stable water table (Slough and Sadleir 1977). This it accomplishes by damming the outlets of slow-moving (low-gradient) narrow streams and lakes. It uses adjacent riparian deciduous habitat for foraging and, of the number of woody or herbaceous plants eaten, prefers aspen, willow, cottonwood and alder species. Its deciduous vegetation consumption has been estimated at 662 g per beaver per day, 216 trees per beaver per year and 0.4 of aspen per beaver per year (Banfield 1977). Clearly, an ample supply is required to maintain a colony. Disturbances which revert an area to the shrub-deciduous successional stages create suitable beaver habitat.

6.6 Deer Mouse

The deer mouse (Peromyscus maniculatus) is a very adaptable species and occurs in most habitats. It favours the dry semi-open or disturbed situation where the invading grasses and forbs provide the required food (i.e. seeds) and cover. It is, as a result, most abundant in the early stages of forest succession (grass-forb) and least abundant in the later, climax stages (Tevis 1956, Hooven 1971, Kirkland 1977). Fluctuations in their populations coincide with seasonal and annual seed crops.

6.7 Townsend's Vole

The Townsend's vole (Microtus townsendii) is unique in Canada to Vancouver Island and the southwestern corner of the B.C. mainland (Anderson and Rand 1943). It is distributed from sea level to timber-line and above -- in subalpine and alpine meadows -- and is characteristically a denizen of salt marshes, moist fields and meadows. It feeds on the underground root stocks of grass, sedge and other succulent plant stems (Banfield 1977). Although a considerable amount of research has been directed at the population dynamics of this species (Hilborn 1974, Boonstra 1976, MacLaren 1977, Beacham 1979), very little is known about other aspects of its life

history. Succulent grass-forb vegetation and dense vegetation cover are hypothesized habitat requirements.

6.8 Wolf

Information on wolf (Canis lupus) ecology and predator-prey relationships on Vancouver Island are summarized by Hatter (1982). Studies on Vancouver Island's population have been directed mainly at their predator-prey relationship with black-tailed deer (Odocoileus hemionus columbianus) and Roosevelt elk (Cervus elaphus roosevelti).

The wolf shows very little habitat preference. Its movements appear to be influenced by topography, roads, and prey density. During the summer, packs are tied to home sites. Den sites (e.g. hollows in stumps, under logs) are reported in mature forest habitats; and rendezvous sites are known to occur in both forested and cutover habitats, often near swamps. Wolf packs travel throughout their territory and are thought to concentrate their hunting activity on ungulate winter ranges.

The major food items of two wolf packs studied on Vancouver Island were, in order of preference, black-tailed deer, Roosevelt elk and beaver (Scott and Shackleton 1980). Deer fawns and elk calves are an important component of their summer dret (Hatter pers. comm.).

Wolf densities and territory sizes are adjusted to total ungulate biomass (Keith 1974, Haber et al. 1976). On Vancouver Island, Hatter (pers. comm.) has demonstrated an inverse relationship between wolf territory size and deer density. At present, predation on deer is particularly severe because of high wolf densities and the combined effects of cougar and bear predation and human deer harvests (Hatter pers. comm.).

6.9 American Black Bear

Black bears (Ursus americanus) are extremely adaptable and a wide variety of habitats are used if cover and food are available. In coastal British Columbia, bears prefer valley bottoms, although they also make extensive use of cutover habitats (Lloyd 1979, Stordeur 1980). Movements and habitat selection are influenced by the distribution, abundance, and

phenology of their major food species (Armstrup and Beecham 1976). Den site selection appears to be flexible although natural cavities, under stumps or in snags which need little preparation, are preferred (Lindzey and Meslow 1976).

Coastal black bears take advantage of seasonal abundant food items. During spring and early summer, sedges, herbs, ferns and the current growth of shrubs are important. In summer and fall, fruits and salmon are used extensively (Lloyd 1977). Berries of the genus Vaccinium are particularly important for building up winter fat stores and therefore are of high survival value (Tompa 1977).

6.10 Raccoon

Raccoons (Procyon lotor) are very adaptable creatures and common close to human populations. They frequent low and mid-elevation conifer and deciduous forests in areas near water. The raccoon is omnivorous and forages on the ground and in the shallow water where berries, birds, fish and crustaceans are eaten.

Raccoons use a variety of den sites including hollow trees, excavated burrows and caves. Tree cavity den sites are usually 3 m above ground and have an entrance between 18 and 43 cm in diameter (Banfield 1977). In areas close to human inhabitation, drainpipes, culverts or barrels are often used as temporary shelter.

6.11 American Marten

Mature conifer or conifer-dominant mixed forests provide the best marten (Martes americanus) habitat (de Vos 1952, Koehler et al. 1975, Koehler and Hornocker 1977, Mech and Rogers 1977, Major 1979, Soutiere 1979, Kelly 1982). Mature mesic forest stands with numerous deadfalls are preferred. During summer, marten use a mosaic of habitats and occur in forests at all stages of succession as long as prey and hunting cover are available. During winter, however, they avoid open habitats. Snow depth (Koehler and Hornocker 1977) and snow crust (Stevenson 1979) were found to adversely affect prey accessibility, thus making canopy cover another important habitat component. The literature generally agrees that

marten require mature forest in winter. Windfalls protruding through the snow act as runways and provide access to the prey beneath (Stevenson 1979). Intensive hunting also occurs at the quamaiq (i.e. snow depression at the base of a tree) where rodent breathing holes are often present (Koehler et al. 1975, Kelly pers. comm.). Kelly (pers. comm.) suggests that the thermal stability of a mature forest is important for minimizing environmental stress. On Vancouver Island, where marten have been trapped in clearcuts during winter (Braun pers. comm.), both the effect of snow on prey accessibility and the relationship between marten and mature forests need further study.

The tangle of down timber is the marten's favourite haunt, as it provides habitat for their prey. On the mainland, small mammals, primarily of the sub-family Microtinae, are the year-round diet staple; red-back voles (Clethrionomys gapperi) are the preferred species (Cowan and MacKay 1950, Quick 1955, Weckwerth and Hawley 1962, Koehler and Hornocker 1977). Other items consumed include insects, birds, and berries. Food habits of marten on Vancouver Island are unknown. The only vole species found on Vancouver Island is the Townsend's vole (Microtus townsendii). Other small mammals species occurring on the Island, and possible prey for the marten are the vagrant and dusky shrew and the deer mouse.

The observed dependence of the marten on mature forest has generated a considerable amount of interest due to increasing forestry pressure on this diminishing resource. The resultant studies (Yeager 1950, Soutiere 1978, Major 1979, Stevenson 1979, Archibald 1980, Kelly 1982, and others), mostly directed at the marten-logging conflict, have helped to elucidate and refine knowledge of marten habitat requirements.

Several authors have quantified forest stand requirements. Soutiere (1979) reports that, in Maine, a residual stand of 20-25 m/ha basal area pole and older trees provide the required summer food and cover. Koehler et al. (1975:35) state that in Idaho "During winter marten need old growth forests (greater than 100 years) on mesic sites with a canopy cover greater than 30 percent." Kelly (1982) reports that in the Prince George area forests must be at least 80 years old before they begin to provide suitable winter habitat.

Since marten are able to use a habitat mosaic, at least in summer, attempts have been made to identify size and pattern requirement parameters. In Maine, three companion studies (Major 1979, Soutiere 1979, Stevenson 1979) identified the following habitat requirements:

1. One male requires an area 10 km^2 of which 50% must remain in undisturbed conifers or partially-cut mixedwoods with a basal area greater than 20 m^2/ha. This 50% must not have openings great than 300 m wide. Male home ranges are mutually exclusive.

2. Females are more restricted to mature forest and their home range of 2.5 km^2 must remain as a contiguous block of softwood or softwood-dominated mixedwood. The block may have 50% of the basal area removed or 20% in small clearcuts less than 300 m wide. Female home range may be within a males home range.

3. In a clearcut forest, a minimum of 25% of the forest must remain as blocks of undisturbed pole-stage and larger conifers to support a residual marten population.

Because marten have been identified as a climax species, it is important that the habitat requirements be identified for Vancouver Island.

6.12 Ermine

Ermine (Mustela erminea) inhabit a mosaic of woodlands and clearings from sea level to 3000 m. In this wide variety of habitat types used, cover is an important habitat component (Banfield 1977). They frequent the boundaries of meadows and riparian zones, preferring boreal conifer and mixed wood forests. Their den sites commonly occur in rodent burrows, although hollow logs and snags are also used.

Ermine forage in open habitat and feed primarily on voles (Microtus and Clethrionomys) and mice (Peromyscus and Mus). Ermine populations are known to experience drastic fluctuations, which coincide with the population cycles of their prey species.

6.13 American Mink and River Otter

Mink (Mustela vison) and river otter (Lutra canadensis) are dependent on the aquatic environment and its associated habitat for food and shelter. They inhabit stream banks, lakeshores, large marshes or swamps, the marine intertidal (mink), and ocean bays (river otter)(Banfield 1977). In freshwater habitats they occupy abandoned beaver lodges, and beaver or muskrat bank burrows for their shelter and den sites. When these sites are unavailable, they use hollow logs and stumps in the adjacent forest. Mink occasionally dig their own burrows; the river otter never does.

Mink on the coastal shores of Vancouver Island feed mainly on crustaceans and fish (Hatler 1976). Small mammals have, however, also been reported as their principle diet item (Banfield 1977). These reported differences in diet probably reflect the differences between coastal and inland mink populations, and food availability, abundance, and preference. The river otter's diet consists mainly of fish, followed by invertebrates, amphibians, and mammals.

6.14 Wolverine

The wolverine (Gulo gulo) is highly mobile and wanders distances up to 125 km without a rest (Cockerton and Herrero 1973); daily forays are usually between 25 to 35 km (Hornocker and Hash 1976). It frequents the forested, hilly or mountainous terrain during spring, summer and fall, only crossing the lower elevation river valleys as it travels from one area to another. It is omnivorous in summer and feeds on a variety of foods (Appendix 13.3). In winter, the wolverine descends to the lower elevations where food is more available. There it is primarily a scavenger, following ungulate herds and feeding on the carrion of the winter dieoff. Van Zyll de Jong (1975:436) suggests that "there is a direct relationship between the biomass and turnover of large herbivore populations and the abundance and distribution of wolverines." However, on Vancouver Island, this is believed not to be the case. Although there are a large number of winter dieoffs of deer on the Island, wolverine

always have been rare. The factors limiting their potential abundance and distribution on the Island are unknown.

The most stable and dense populations are in mountainous, remote or sparsely populated areas. The relative inaccessibilty afforded by this habitat appears to be an important habitat component. Indirect evidence from declining production of wolverine pelts and the disappearance of the species from areas with relatively dense human populations suggest that exploitation by man is a factor affecting wolverine numbers (van Zyll de Jong 1975).

6.15 Cougar

Cover is an important component of a cougar's (Felis concolor) habitat. On Vancouver Island, cougar appear to avoid open clearcut areas (Dewar and Dewar 1975). In Idaho, Seidensticker et al. (1973) observed that in winter the cougar's home range was largely restricted to mature timber and during the non-winter months cougar had a tendency to use the edges of openings rather than the opening. Cougar studies by the Dewars confirm this for Vancouver Island as well. Dewar and Dewar (1975) have also shown that home ranges of male cougar can encompass more than one watershed. Seidensticker et al. (1973) report that although the summer and winter home areas of a resident cougar were fairly distinct, they were usually contiguous. This is probably also true of cougar range on Vancouver Island.

Cougar movements are influenced by cover, drinking water and prey. Black-tailed deer, Roosevelt elk and beaver are major prey species on the Island.

Suitable den sites are also required, but the variety used (caves, among rock crevices, tree or bank overhangs, hollow stumps, thickets) does not make their availability a limiting factor to cougar habitat requirements.

7 EFFECTS OF INTENSIVE FOREST MANAGEMENT

Very little research has been conducted on the effects of intensive forest management on non-ungulate mammal species of Vancouver Island. Of the information available, most is from research conducted on the North American mainland. Species that have received the most attention -- because of either their big game or furbearer status, or the economic cost their damage imposes on the forest industry -- include marten, wolf, cougar, black bear, beaver, red squirrel, and small mammals.

This information and what is known of species habitat requirements (Section 6) form the basis of this analysis. The results are presented in Appendix 13.6.

7.1 Vagrant Shrew, Dusky Shrew, Deer Mouse, and Townsend's Vole

Compared with that available on other non-ungulate mammals, the literature on the effects of intensive forest practices on small mammals is substantial (Tevis 1956, Hooven 1968, Gashwiler 1970, Hooven 1971, Fala 1975, Sullivan 1979, Geier and Best 1980). In general, the response of small mammals to various forest practices is dependent upon the resultant food, cover, and moisture regime available.

Clearcutting and/or burning produces a more xeric site and allows wind-dispersing grasses and forbs to quickly invade. These herbs provide food and cover for granivores (e.g. deer mouse) and grazers (e.g. Townsend's vole) and these species consequently increase in number (Kirkland 1977). For example, the deer mouse (a granivorousomnivore), usually the most abundant species on disturbed areas, has been found to occur in numbers 2 to 10 times greater on logged sites than unlogged sites (Sullivan 1979). The observed increase in numbers is greatest in the summer and fall. In the spring, however, numbers are reported to be similar to that of forest populations. Because of this dramatic annual population fluctuation, Sullivan (1979) has questioned the superiority of logged areas as deer mouse habitat. Deer mouse numbers approach those observed in mature forest at the sapling-pole stage.

No information is available on the response of Townsend's vole to forestry practices. As a grazer in marshes and moist meadows, it is likely affected by forest practices that modify the grass-forb vegetation and its moisture regime. Hooven and Black (1976) found that the marsh shrew (Sorex bendrii), whose habitat preference is similar to the Townsend's vole, was present 2 years after logging (45% of ground bare) and 3 years after slashburning. The optimal trapping site was in the dense riparian vegetation and the authors concluded that vegetation development favoured the marsh shrew presence. A similar response is hypothesized for Townsend's vole.

Insectivores (e.g. shrews) also increase following clearcutting, although changes in their relative abundance are less than those of grazers and granivores (Kirkland 1977). Shrew densities are dependent on the ground debris, herbs and humus layer available for cover and as insect habitat (Hooven 1971). Hooven and Black (1976) in their study in western Oregon, found that populations of vagrant shrew were lowest (7% of the total vagrant shrew catch) on cut and burned sites (small debris burned, larger culls remained). On unburned clearcuts, numbers were substantially higher (35%) but less than on the undisturbed area (60%). In western-central Oregon, Gashwiler (1970) found, over an 11-year period, that although numbers were low, more vagrant shrews were caught in virgin forest than on the clearcut. He concluded that virgin timber is the better habitat. It is probable that the dusky shrew would have a similar response, since they prefer a wet habitat.

Although studies on habitat alteration are numerous, only a few identify the response of small mammals to fertilization and herbicide application. A study in western Washington found that urea fertilization had no harmful effect on deer mice (Postovit 1976). The moist conditions at the time of application aided in its rapid dissipation and hence its short term availability (1-2 days). It was concluded that other small mammals would not be affected. In B.C., studies by Sullivan and Sullivan (1981, 1982) on the responses of deer mouse and small mammal populations to forest herbicide application also support this conclusion. In these studies, the glyphosate herbicide Roundup was found to have no negative

effect on these small mammal populations, at least in the first year after application.

Aerial application of 2,4,5-T in West Virginia on a conifer plantation (Norway spruce, [Picea abies]) resulted in no significant change in the ranked order of species after treatment (Kirkland 1978). Total numbers of small mammals were greater after treatment. Populations of shrews (Soricidae) and mice (Cricetinae) increased significantly; voles (Microtinae) declined slightly. It was concluded that because of their food habits, soricids and cricetines (i.e. primarily seed-eaters and insectivores, respectively) are less susceptible to a decrease in the vegetation food resource or to herbicide ingestion. Microtinae, however, being primarily grazers, are affected by a decrease in their vegetation food resource and are more susceptible to herbicide toxicity. Their failure to increase following treatment is believed to be due to an increase in predation pressure as a result of the decrease in vegetation cover.

The few studies on the effect of forest insect spraying on small mammals indicate that, when applied as recommended, none of the currently used insecticides are damaging to mammals (Buckner and McLeod 1975). They suggest, however, that the use of insecticides may indirectly affect insectivorous mammals (i.e. shrews and bats) by creating a disruption in their food source. The authors report that for the widely used forest insecticide, fenitrothion, reductions in adult rodent populations recovered within the treatment year and no detectable effects were observed the following year.

7.2 Bats

No information is available on the effects of intensive forest management on bat species. The following discussion presents some hypothesizes based on habitat requirement information.

Clearcutting eliminates the roosting sites of all cavity-roosting species (lifeform 5). Although some of these species are adapted to urbanization, clearcutting alters habitat without substituting man-made alternative cavity-roost sites. The stage at which a regenerating forest

becomes suitable habitat for tree cavity-roosting bats is unknown. Foliage-roosting bats (lifeform 4) are also affected; however, stands for these species will probably be suitable before cavities form.

Because bats are aerial foraging insectivores, forest practices that open up the forest canopy (such as clearcutting and thinning) are beneficial. On the other hand, forest practices that are potentially harmful to their insect prey base -- at least locally -- include those that involve herbicide or insecticide application, or that result in changes to water quantity or quality (water being an important foraging site for many bat species).

7.3 Vancouver Island Marmot

Studies assessing the effect of forest practices on marmot colonies have not been conducted. However, due to its recent endangered status, the Vancouver Island marmot is now receiving a great amount of attention (Miller 1980, Routledge and Merilees 1980, Vancouver Island Preservation Committee 1981) and the potential impacts of intensive forest practices on it have been hypothesized. Because marmots are not forest inhabitants, this impact is indirect.

In her review of the Vancouver Island marmot, Carson (1978) suggested that forest practices limit marmot populations by creating post-logging habitats that are not conducive to species dispersal and that lead to increased vulnerability to predation during dispersal. Also, the greater accessibility by humans to the marmot's formerly remote habitat increases the probability of recreational exploitation in these areas (e.g. through skiing and hunting). Changes in marmot habitat and increased harassment, that may interfere with marmot behaviour (e.g. feeding, breeding) likely follows. According to Smith (1982), however, there is no evidence that logging or ski developments have interfered with marmot colonies. He does indicate that destruction of their habitat is due to the encroachment of man's activities. Since the Vancouver Island marmot is both an endemic and endangered species, it is critical that the conditions limiting marmot populations be clarified. Logging is a potential factor. The role of slash-covered habitat needs further investigation.

7.4 Red Squirrel

Red squirrels are dependent upon coniferous seeds for survival, and are restricted to habitat that has mature seed-producing trees. Clearcutting eliminates this habitat, but forest practices that advance forest succession are likely beneficial. Wolff (1975) found that, following clearcutting, all territories were vacated, adjacent shelterwood population density decreased, and individual home range size increased. Populations in adjacent undisturbed stands remained stable or increased slightly. The suitability of a shelterwood is dependent on the spacing of cone-bearing trees and cone production. In the Prince George and Williams Lake areas, damage by red squirrels to reforested lodgepole pine stands indicates that stands with trees greater than 60 mm in diameter provide suitable red squirrel habitat (Sullivan 1981). In the Sayward Forest on Vancouver Island, dense stands of 25-year-old Douglas-fir are used (Nyberg pers. comm.).

7.5 American Mink, River Otter, American Beaver and American Water Shrew

Mink, river otter, beaver and the water shrew are all dependent on the aquatic medium and its associated environment for food and shelter. Because of this dependence, intensive forest practices that alter the quality of this habitat likely affect the presence of these species. The effects of forest practices on water quality and quantity are well known (Bell et al. 1974, Sadoway 1986). Changes in water quality mainly affect the food source of these species. Clearcutting, burning, scarification, and possibly herbicide brush control are known to adversely affect fish and other aquatic species under certain circumstances, and therefore potentially the prey of the river otter, mink, and water shrew. (The federal Fisheries Act [1970] does, however, provide some protection of the food source.) In addition, increases in the volume and velocity of waterflow can flood and destroy the shoreline bank burrows of mink, river otter and water shrew.

Forest practices that remove riparian vegetation eliminate available cover and affect species movement and dispersal. The degree of the impact

depends on the extent of the disturbance, that is, the number of watersheds logged (Archibald pers. comm.).

It is hypothesized that the length of time for which riparian habitat remains unsuitable is short. Shrubs may provide adequate cover, and as deciduous trees re-establish, preferred beaver habitat is created. Re-invasion by the river otter is dependent on the availability of an abandoned muskrat or beaver borrow.

Mink, river otter and beaver are furbearers and therefore are sought by man. Logging, by increasing the accessibility of many formerly remote areas, increases their susceptibility to trapping.

7.6 Wolf

The wolf is dependent on ungulate prey as the food source and consequently is affected by intensive forest management practices that alter the quantity, quality and distribution of deer and elk habitat on Vancouver Island.

7.7 American Black Bear

Logging and opening the forest tend to increase populations of black bear (Lauckhait 1955) by providing vast areas of new spring and summer range (Stordeur 1980). As intensive forest practices are refined -- especially brush control methods -- the availability of fruit-producing shrubs as forage for bears will likely decline. However, bears are adaptable to a diet within wide limits and suggests that this impact will likely be minor.

The flexibility a black bear exhibits for selecting den sites suggests that habitat alteration would not limit populations. However, Lindzey and Meslow (1976:242) state that "Intensive logging will decrease the availability of preferred den sites, expecially as the time between subsequent cuts is shortened." They reported that yearlings found suitable den sites in 7- to 10-year-old forest stands, whereas adult bears denned in cuts over 18 years old. Whether young and adults use different den site selection criteria or whether adults occupy the best site forcing yearlings into less optimal sites is unknown.

Perhaps the greatest effect created by logging is the human-bear conflict. With logging opening up formerly remote areas, black bear habitat has become more accessible to recreationists. The black bear-human problem is well known (Tompa 1977, B.C. Ministry of Environme 1980a) and preventative measures can be taken.

7.8 Raccoon

Because the raccoon is very adaptable, the effect of intensive forestry practices is probably minimal. A decrease in the water quality and thus a decrease in aquatic food supply may be the most damaging consequence. The extent or overall effect of intensive forest practices on their habitat is unknown.

7.9 American Marten

Yeager (1950) stated that logging is the single most destructive factor to marten populations. Mech and Rogers (1977) thought that clearcut logging and increased trapping pressure (resulting from increased accessibility) were the major factors contributing to population declines and reduced marten distribution. However, Koehler et al. (1975) concluded that the quality of marten habitat is dependent on, and varies with, the size, logging intensity, and moisture regime of the site. A xeric site resulting from logging and/or fire provides poor marten habitat; cover is inadequate and inhabiting small mammal species appear to be low-preference foods. Where logging has occurred on mesic sites, or where forest succession has progressed naturally or by intensive forest management, more productive marten habitat results, with good cover and the habitat of their preferred prey (voles) provided.

Koehler et al. (1975) observed that male marten would cross clearcuts up to 300 m wide, but they did not appear to hunt in these areas. Females rarely ventured into open areas. On Vancouver Island, marten have been trapped in clearcut slash (Braun pers. comm.). This suggests that slash and large ground debris provide adequate cover in open areas.

Although marten are able to use a successional forest mosaic during summer, in the winter -- their most critical period -- they require a forest stand with a sufficient canopy and accummulation of large debris to provide adequate cover and prey accessibility. The impact of clearcutting is directly proportional to the intensity. It has been suggested that maintaining a canopy cover greater than 30% would not adversely affect marten habitat (Koehler et al. 1975).

The effect of intensive forest practices can be minimized if the size, pattern and structure of the resultant forest mosaic is carefully planned (e.g. see Section 6.11). A diversity of forest types, which maintains sufficient winter habitat to support a viable marten population, would produce more marten over time (Koehler et al 1975).

7.10 Ermine

Very little information is available on the influence of intensive forest practices on ermine. Practices that affect their small mammal prey and the hunting cover within the habitat of their prey are thought to have the greatest impact on ermine.

Forest practices that open the forest canopy likely benefit ermine populations. Clearcutting is known to increase the abundance of many species of small mammals, particularly those of the genus Peromyscus (Tevis 1956, Gashwiler 1970, Hooven 1971, Fala 1975, Kirkland 1977, Geier and Best 1980). Because ermine populations are directly influenced by the abundance of voles and mice (Banfield 1977), the increase in prey numbers should correspondingly increase the ermine population. Gashwiler (1970) and Hooven (1971) found that in clearcuts and burned areas (only small debris burned), ermine, although present, were in low numbers. Lack of sufficient hunting cover was suggested as the cause. Forest practices that decrease the ground cover probably reduce the suitability of ermine habitat.

Rodent control, a reforestation practice implemented to reduce the number of small mammals (Pank 1974) and therefore ermine prey, could also negatively affect ermine populations. Currently this practise is not used in operational silviculture on Vancouver Island (Benskin pers. comm.).

7.11 Wolverine

Of the few papers written on the wolverine, none have been concerned with the effects of forest practices. A study now in progress in Alaska on the ecology of the wolverine has placed part of its focus on the impact of petroleum resource development on this species (Mogun 1980). This study should give some insight into the effects of habitat alteration on the wolverine.

Based on perceived habitat requirements, it is believed that wolverines would be affected by forestry practices that (1) alter predator-ungulate interrelationships and (2) increase human accessibility. Because the wolverine depends on the efforts of other predators (such as wolf and cougar) and on ungulate winter dieoff for the majority of its food, it is ultimately affected by forestry practices that alter the abundance and distribution of ungulate species. In addition, as logging advances into the higher elevations, accessibility and consequently trapping pressures increase.

7.12 Cougar

Directly dependent on the abundance of its prey species, the cougar is affected by changes in ungulate populations, primarily that of black-tailed deer. The existing extent of cougar habitat will probably decrease in the next few years, corresponding to a decrease in the available winter habitat for black-tailed deer. The effect of forest practices on the predator-prey interrelationship between cougar and deer is not known.

8 EFFECTS OF NON-UNGULATE MAMMALS ON REFORESTATION

Although this analysis is primarily concerned with documenting the effects of intensive forest practices on non-ungulate mammals, it was felt that it is important to note, even if only briefly, the effect these species have on forest practices.

8.1 Costs

Considerable interest and energy have always been directed towards studying the effects of mammals on reforestation (Pank 1974). Seed-eating mammals, lagomorphs, and ungulates have received the most attention. Of the non-ungulate mammal species that occur on Vancouver Island, these include the vagrant shrew (S. vagrans), dusky shrew (S. obcurus), red squirrel (T. hudsonicus), beaver (C. canadensis), deer mouse (P. maniculatus), Townsend's vole (M. townsendii), black bear (U. americanus), eastern cottontail (Sylvilagus floridanus), European rabbit (Oryctolagus cuniculus), and the house mouse (Mus musculus). The latter three species have been introduced to the Island.

After clearcutting and site preparation, seed-eating mammals (granivores), which inhabit the early successional stages, are a major problem in direct seeding programs. The most troublesome species is the ubiquitous deer mouse (Sullivan 1978). As the stand develops into shrub-seedling and pole-sapling stages, browsing by lagomorph species cause the greatest amount of damage. Before the stand matures, it becomes suitable habitat for red squirrels. At this stage, red squirrels cause considerable damage because of their voracious appetite for coniferous seeds and their habit of girdling branches and treetops. Bears are known in some instances to severely claw the bark of trees, but the extent of this damage is unknown. The beaver, although direct damage to trees within forest stands is insignificant, has the potential to flood roads and large areas of valuable timber.

Currently, forest stand damage on Vancouver Island is caused primarily by ungulates (Schuerholz per. comm.). Direct seeding is not a common practice, in part because of seed-eating small mammals. Some bear damage is evident but it is, as yet, not of economic consequence (Schuerholz pers. comm.). In the Lake Cowichan-Nanaimo area, some cottontail damage is anticipated as the result of the northerly dispersion the population since 1982 (Schuerholz pers. comm.).

8.2 Benefits

The potential benefits of mammals on reforestation have historically been ignored. Recent studies however indicate that small mammals may play an important vectorial role in the innoculation of mycorrhizae fungi in forest stands (Trappe and Maser 1977, Maser and Trappe 1978, Maser et al 1978).

These authors hypothesize an interrelationship between host trees, hypogeous mycorrhiza-forming fungi, and small mycophagous mammals. The obligatory symbiotic relationship between hypogeous mycorrhiza-forming fungi and most higher plants forms the framework. Small mammals consume hypogeous fungi in their diet and deposit, in their feces, viable fungal spores. These spores germinate and form a eusymbiotic relationship with their host tree species. In this manner, re-innoculation occurs, genetic variability is maintained, and innoculation of new areas occurs, perpetuating stand quality. Research is required to elucidate this interrelationship for Vancouver Island, and the traditional viewpoint of the small mammal-reforestation conflict needs to be re-evaluated.

Another important benefit is that insectivorous mammals such as shrews and bats may play an important role in controlling forest insect pests. Although no one species is likely the dominant factor, the compounded effect of a number of species may aid in preventing insect outbreaks. The role insectivorous mammals play in affecting forest insect pest outbreaks needs further investigation.

9 RESEARCH RECOMMENDATIONS

The preceding analysis, based on a review of the literature, indicates the scope of available information and identifies the areas where information is lacking. It provides the basis for a number of recommended study topics.

Clearly, species distributions and inventories for most of Vancouver Island's non-ungulate mammals are required. This information is critical to species management. While it is not necessary that detailed large-scale distribution maps be prepared for each species, some knowledge of where species occur is important for study site selection for ecological research and hypothesis testing of habitat values (Nyberg pers. comm.). The Fish and

Wildlife Branch and other agencies are encouraged to collect this data. A species priority list (Section 10) is provided as a guideline for species selection.

The criteria used to choose species for study were: 1) low quality and/or quantity of information concerning species habitat requirements; and 2) high sensitivity to intensive forest practices. Consequently, all species are not represented. Recommended study topics are designed to clarify species habitat requirements and the extent of their wildlife-forestry interaction.

The following topics are presented in taxonomic order and not by priority.

Small mammals

What is the interrelationship between small mammal mycophagists and the quality of reforested stands?

Which host tree-fungi eusymbiots are consumed by which mammal mycophagists?

Bats

What impact do bats have on forest insect pests?

What insect pest species are consumed by which bat species in coastal forest ecosystems?

What role do bats play with other insectivore species (primarily birds) in controlling insect outbreaks?

What criteria do tree-roosting bats use when selecting roosting sites?

What habitat characteristics are important?

What criteria do foliage-roosting bats use when selecting roosting sites?

What habitat characteristics are important?

Red squirrel

What is the earliest stage of succession that provides suitable red squirrel habitat in coastal forests?

- tree species (%)
- age (dbh, ht, canopy cover)
- stand density (trees per area)

What factors influence nest site selection?

Are different tree species used for food and shelter in coastal forests?

What type of vegetation structure is necessary for dispersal?

Vancouver Island marmot

A comprehensive list of the areas requiring study are presented in the "Vancouver Island Marmot Five-Year Plan, 1981-1986" (Hebert 1981). Bob Milko is currently evaluating the study topics to choose a topic for his Masters thesis.[1]

Wolf

How do forestry practices affect wolf-ungulate relationships (e.g. roads, stand heterogeneity)?

What habitat management techniques would be useful in mitigating wolf-ungulate interactions in favour of deer and elk?

How do wolves use habitat to find deer before and after logging?

How does the habitat mosaic (juxtaposition, type) affect predator-prey avoidance?

Black bear

How adaptable is den site selection?

- den site characteristics in early succession
- adult vs yearling preferences

How important is mature timber for feeding, resting, and cover?

American marten

What are the food habits of marten on Vancouver Island?

What characteristics of a forest determine suitability of marten winter habitat?

What is the relationship between ground debris and prey availability ?

Does snow depth and structure affect hunting strategy and prey availability in coastal forests?

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[1] Prior to publication, Milko, R.J. 1984. Vegetation and foraging ecology of the Vancouver Island marmot (Marmota vancouverensis) was completed.

Is thermal cover a significant factor in the winter ecology of marten in a coastal mesothermal forest?

What percent canopy cover is required in coastal forests?

- size of forest stand to maintain a viable population

What stand structure and species composition is required?

What is the relationship between marten social structure and habitat use?

- polygamous or monogamous
- territory establishment
- size and structure of forest mosaic

Ermine

What is the relationship between ermine and mature forest?

What activities are restricted to mature forests?

What forest types are seasonally preferred habitats?

What is the impact of rodent control on ermine populations?

- prey availability
- direct poisoning

Wolverine

Is the subspecies of wolverine found on Vancouver Island different than the mainland subspecies?[1]

What habitat is used during the breeding season?

- structure and composition of forest habitat
- elevation of habitat used
- type of den site
- duration of usage

What are the feeding habits and movements of wolverine during winter?

- habitat association and relationships with predator species such as wolf and cougar and with prey species such as deer and elk

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[1] Subsequent to the writing of this paper, a bibliography on the wolverine (Bianci 1982a) and an investigation of the taxonomic status of Vancouver Island's wolverine population (Bianci 1982b) has been completed.

Cougar

What effect do forest practices have on the relationship between cougar and deer?

- cougar density
- population structure
- distribution and movement
- prey vulnerability

10 SPECIES PRIORITY

To determine species research priorities, non-ungulate mammal species were ranked according to the following criteria:

1. present status
2. economic importance to man, i.e. hunted and/or trapped on Vancouver Island
3. state of present knowledge on species habitat requirements
4. applicability of extrapolating mainland studies to species on Vancouver Island
5. predator or prey
6. perceived impact of intensive forest management practices, i.e. species sensitivity
7. feasibility of conducting research, e.g. research on wolverine is logistically very difficult

Species' ratings for these criteria are presented in Table 8.

This analysis identified the Vancouver Island marmot as the number one priority species. Species are listed as follows:

HIGH PRIORITY	MODERATE PRIORITY	LOW PRIORITY
Vancouver Island Marmot	Dusky Shrew	American Water Shrew
Bats	Vagrant Shrew	Raccoon
Red Squirrel	Townsend's Vole	Wolf
American Marten	American Beaver	River Otter
	Deer Mouse	American Mink
	Wolverine	Cougar
	Ermine	
	American Black Bear	

TABLE 8. Species priority rating list

Species	Present status	Econ. Impt.	Hab. Reg. Info.	Info. Applic to VI	Predator or Prey	Logging Impact	Research Feasibility	Total	Priority Ranking
Dusky Shrew	0	0	0	0	2	1	2	5	3
Vagrant Shrew	0	0	0	0	2	1	2	5	3
American Water Shrew	0	0	1	0	0	0	2	3	5
Bats	0	0	2	2	0	1	1	6	2
Vancouver Island Marmot	2	0	1	1	1	1	1	7	1
Red Squirrel	0	1	0	0	1	2	2	6	2
American Beaver	0	1	0	0	1	1	2	5	3
Deer Mouse	0	0	0	0	2	1	2	5	3
Townsend's Vole	0	0	0	0	2	1	2	5	3
Wolf	0	2	0	0	0	0	1	3	5
American Black Bear	0	1	0	1	0	1	1	4	4
Raccoon	0	1	0	0	0	0	1	2	6
American Marten	0	1	1	1	0	2	1	6	2
Ermine	0	1	1	1	0	0	1	4	4
American Mink	0	1	0	0	0	0	1	2	6
Wolverine	1	1	1	1	0	1	0	5	3
River Otter	0	1	0	1	0	0	1	3	5
Cougar	0	1	0	0	0	0	1	3	5
Rating Values	0 - not endangered 1 - rare 2 - endangered	0 - low 1 - hunted or trapped 2 - hunted or trapped	0 - mod. to high 1 - low 2 - nil	0 - mod. to high 1 - low 2 - nil	0 - predator 1 - prey for few 2 - prey for lg. #	0 - low sensitivity 1 - mod. sensitivity 2 - very sensitive	0 - feasible, inexp. 1 - feasible, exp. 2 - infeasible, exp.		

11 SUMMARY

The conflicts between forest and wildlife resource management have generated research into the habitat requirements and effects of intensive forestry practices on some mammal species. This research has generally been directed at high priority ungulate species (deer and elk) or reforestation-damaging small mammals and consequently, there is a tremendous disparity of information among species. This disparity is evident in this analysis of non-ungulate mammals of Vancouver Island.

Due to the lack of information specific to Vancouver Island, species information from mainland North America was used in this analysis. Species life history and habitat use information formed the basis for discussion of species habitat requirements. The effects of forestry practices on non-ungulate species were discussed, and documented and hypothesized wildlife-forestry interactions were presented.

The synthesis of this information revealed that species distributions for all non-ungulate mammals are incomplete, and that information on the habitat requirements and effects of forest practices are sparse for most species. Species chosen for study were evaluated on the quality and quantity of information available on their habitat requirements and on the species' vulnerability to intensive forestry practices. Recommended study topics are designed to clarify habitat requirements and the extent of wildlife-forestry interactions for these species. The Vancouver Island marmot is identified as the number one priority species. American marten, bats and red squirrel are high priority species; moderate and low priority species are also listed.

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13 APPENDICES

13.1 Non-ungulate mammals of Vancouver Island 49
13.2 Lifeform descriptions 51
13.3 Species life history by lifeform 53
13.4 Species vs habitat component 62
13.5 Species vs successional stage 63
13.6 Effects of intensive forest management 64
13.7 Personal communications 66

APPENDIX 13.1 Non-ungulate mammals of Vancouver Island

INDIGENOUS SPECIES

Common Name	Scientific Name
Vagrant Shrew	*Sorex vagrans*
Dusky Shrew	*Sorex obscurus*
American Water Shrew	*Sorex palustris*
Little Brown Bat	*Myotis lucifugus*
Yuma Bat	*Myotis yumanensis*
Keen's Bat	*Myotis keenii*
Long-eared Bat	*Myotis evotis*
Long-legged Bat	*Myotis volans*
California Bat	*Myotis californicus*
Silver-haired Bat	*Lasionycteris noctivagans*
Townsend's Big-eared Bat	*Plecotus townsendii*
Big Brown Bat	*Eptesicus fuscus*
Hoary Bat	*Lasiurus cinereus*
Vancouver Island Marmot	*Marmota vancouverensis*
Red Squirrel	*Tamiasciurus hudsonicus*
American Beaver	*Castor canadensis*
Deer Mouse	*Peromyscus maniculatus*
Townsend's Vole	*Microtus townsendii*
Wolf	*Canis lupus*
American Black Bear	*Ursus americanus*
Raccoon	*Procyon lotor*
American Marten	*Martes americana*
Ermine	*Mustela erminea*
American Mink	*Mustela vison*
Wolverine	*Gulo gulo*
River Otter	*Lutra canadensis*
Cougar	*Felix concolor*

APPENDIX 13.1 Non-ungulate mammals of Vancouver Island (continued)

INTRODUCED SPECIES

Common Name	Scientific Name
Eastern Cottontail	*Sylvilagus floridanus*
European Rabbit	*Oryctolagus cuniculus*
Grey Squirrel	*Sciurus carolinensis*
Muskrat	*Ondatra zibethicus*
Roof Rat	*Rattus rattus*
Norway Rat	*Rattus norvegicus*
House Mouse	*Mus musculus*
Nutria	*Myocaster coypus*

APPENDIX 13.2 Lifeform descriptions

Lifeform 1: Reproduces in caves.
Feeds in the air.

Townsend's Big-eared Bat (Plecotus townsendii)

Lifeform 2: Reproduces on ground without specific water.
Feeds on the ground.

Wolverine (Gulo gulo)

Lifeform 3: Reproduces primarily in conifers.
Feeds in trees, or on the ground.

Red Squirrel (Tamiasciurus hudsonicus)

Lifeform 4: Reproduces in conifer or deciduous trees.
Feeds in the air.

Hoary Bat (Lasiurus cinereus)

Lifeform 5: Reproduces in hole made by another or in natural cavity.
Feeds on ground, in water, or in the air.

Little Brown Bat (Myotis lucifugus)
Yuma Bat (Myotis yumanensis)
Keen's Bat (Myotis keenii)
Long-eared Bat (Myotis evotis)
Long-legged Bat (Myotis volans)
California Bat (Myotis californicus)
Silver-haired Bat (Lasionycteris noctivagans)
Big Brown Bat (Eptesicus fuscus)
Wolf (Canis lupus)
American Black Bear (Ursus americanus)
Cougar (Felix concolor)

APPENDIX 13.2 Lifeform descriptions (continued)

Lifeform 6: Reproduces in burrow underground.
Feeds on or beneath ground.

Vagrant Shrew (Sorex vagrans)
Dusky Shrew (Sorex obscurus)
Deer Mouse (Peromyscus maniculatus)
Townsend's Vole (Microtus townsendii)
Vancouver Island Marmot (Marmota vancouverensis)
Ermine (Mustela erminea)

Lifeform 7: Reproduces in burrow underground.
Feeds on the ground or in the water.

American Mink (Mustela vison)
American Beaver (Castor canadensis)
River Otter (Lutra canadensis)
American Water Shrew (Sorex palustris)

APPENDIX 13.3 Species life history by lifeform

The information presented in the following tables was compiled from the following sources.

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Complete citation included in the Section 12.

APPENDIX 13.3 Species life history by lifeform (continued)

Lifeform 1: Reproduces in caves.
Feeds in the air.

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATORS	HABITAT REQUIREMENTS
Townsend's Big-eared Bat Plecotus townsendii	open-type dry forests from arid desert scrub to humid coast regions	Lepidoptera, perhaps feeds entirely on moths	primarily caves; also old mine shafts, buildings	unknown	unknown	caves or crevices for roosting and breeding; especially intolerant of human disturbance to maternity colonies and hibernacula

Lifeform 2: Reproduces on ground without specific water.
Feeds on the ground.

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATORS	HABITAT REQUIREMENTS
Wolverine Gulo gulo	wooded mountain areas; alpine/sub-alpine; 1050-2800 m; in winter, frequent valley bottoms	in winter, primarily scavengers, follow ungulate herds; in summer, omnivous; small mammals; vegetation/berries, insects, carrion	caves, snags, logs, under overhanging branches, among boulders, rock-ledges	territorial; extensive home range; daily movements up to 32 km	wolf	low human disturbance; den sites - logs, snags, rocky areas, caves; winter carrion food supply

APPENDIX 13.3 Species life history by lifeform (continued)

Lifeform 3: Reproduces primarily in conifers.
Feeds in trees or on the ground.

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATORS	HABITAT REQUIREMENTS
Red Squirrel Tamiasciurus hudsonicus	coniferous forests	primarily conifer seeds; also fruits, nuts, fungi, tree buds, bird eggs	tree cavities, under stumps, in burrows	territorial; home range is between 1.1 and 2.4 ha	important prey items: marten, raptors, mink, lynx, snake; man	seed-producing coniferous forests to provide food; suitable nest sites

Lifeform 4: Reproduces in conifer or deciduous trees.
Feeds in the air.

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATORS	HABITAT REQUIREMENTS
Hoary Bat Lasiurus cinereus	forests of medium and large trees with dense foliage	primarily moths	foliage of trees	unknown	unknown	trees with dense foliage are needed for roosting and breeding

APPENDIX 13.3 Species life history by lifeform (continued)

Lifeform 5: Reproduces in hole made by another or natural cavity.
Feeds on the ground, in water, or the air

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATOR	HABITAT REQUIREMENTS
Little Brown Bat *Myotis lucifugus*	a variety of forested habitats used, but prefers areas closely associated with water	forages for insects over water	buildings, caves, mines, tree cavities	unknown	mink, raccoons, voles, snakes	snags for roosting; caves or mines for hibernating; permanent water for feeding
Yuma Bat *Myotis yumanensis*	open clearings closely associated to water; riparian zones	forages for insects over water	buildings, snags, crevices, caves	unknown	unknown	caves, crevices, snags, buildings, mines, for roosting and breeding sites; permanent water for foraging
Keen's Bat *Myotis keenii*	in B.C. prefers dense timber with water body close by	forages over water, along forest edge or clearings for insects	snags, cliff faces buildings, caves	unknown	unknown	trees, snages, or caves for roosting and breeding; water for foraging site
Long-eared Bat *Myotis evotis*	in B.C. prefers coastal forest regions where rock outcroppings prevail	beetles, moths and other insects	snags, caves, mines, buildings	unknown	unknown	snags, caves, and trees for roosting and breeding sites
Long-legged Bat *Myotis volans*	forested areas; spruce/sub-alpine forests	forages over water or woodland clearings for insects	snags, cliff crevices, caves mines	unknown	unknown	trees, snags and crevices for roosting and breeding sites; possibly water for feeding and drinking
California Bat *Myotis californicus*	variety of habitats from semi-arid to well forested area	beetles and moths	crevices in trees, snags, buildings; caves and mines	unknown	unknown	crevices in trees or snags, caves, and mines for roosting and breeding
Silver-haired Bat *Lasionycteris noctivagans*	prefers woodland or forested areas with ponds or streams	forages over water for insects, principally moths	trees, snags, rock crevices	unknown	unknown	tree or snags for roosting and breeding; water for foraging site

APPENDIX 13.3 Species life history by lifeform (continued)

Lifeform 5: Reproduces in hole made by another or natural cavity. Feeds on the ground, in water, or the air

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATOR	HABITAT REQUIREMENTS
Big Brown Bat *Eptesicus fuscus*	variety of habitats; forest openings, meadows, urban areas	forages in open areas for insects, primarily beetles	snags, trees, buildings, caves	unknown	unknown	snags, trees, caves, crevices or buildings for roosting and breeding sites
Wolf *Canis lupus*	variety of habitats; alpine to valley, coniferous and deciduous forests, meadows	ungulate species are the major prey item, prefers deer species; also beaver	roots of windfalls, caves, hallow logs roots beneath rock ledges	during summer wolf pack occupies a fixed home range between 43 and 61 km^2	man	ungulate species for food; suitable den sites
American Black Bear *Ursus americanus*	variety of habitats used; prefers mature forest mosaic with shrub field, meadows, swamps or berry patches	omnivorous; roots, fruit, nuts, fish, small rodents, insects	cave, hollow log, windthrown stump	home range between 5.2 and 52 km^2	man, wolf	suitable den sites—hollow logs, windthrown stumps, caves; abundance of fruit-bearing shrubs
Raccoon *Procyon lotor*	forested areas, coniferous or deciduous, near water; low and mid elevations	omnivorous; forages on ground or in shallow water for arthropods, fish, frogs, small mammals; also fruits, seeds, and insects	hollow trees, burrows, caves	only defends area immediately around den site; mean home range size 114 ha	man	hollow trees, logs or snags for den sites; water as feeding site
American Marten *Martes americanus*	mature conifer or softwood-dominant mixed forests with an abundance of windfalls preferred	small rodents, primarily voles (red-backed voles preferred), squirrels, hares, insects, birds, fruit.	cavities in large trees or snags	home range: females 65 ha; males 260 ha	man	mature timber with an abundance of windfalls
Cougar *Felix concolor*	mountainous terrain; canyon, rimrock, swamps and wooded river valleys to dense coniferous forests; 0-3000 m	primarily deer, also wapiti, beaver	caves, trees, crevices among rocks, stumps, hollow banks	home ranges overlap; in Idaho -- 13-52km^2 for females; 65-250km^2 for males	man	suitable den sites in rock crevices and caves; large ungulates (primarily deer) for food; suitable vegetation cover

APPENDIX 13.3 Species life history by lifeform (continued)

Lifeform 6: Reproduces in burrow underground.
Feeds on or beneath ground.

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATOR	HABITAT REQUIREMENTS
Dusky Shrew Sorex obscurus	marshy, damp, riparian areas in a variety of cover types; prefers mossy forests, willow clad banks, horsetail stands along streams, and sphagnum bogs	eats insect larvae and adults, earthworms, small invertebrates, plant matter among litter layer	ground litter and debris	home range 1200 m^2	birds, terrestrial carnivores	moist soil; forested area with considerable litter and downed material
Vagrant Shrew Sorex vagrans	damp areas in a variety of cover types; humus layer in fields, forests, riparian areas in the Douglas-fir Biogeoclimatic Zone	insects, grubs, seeds, found among litter	ground litter and debris	unknown if different than S. obscurus	birds, terrestrial carnivores	damp soil; considerable litter or humus and downed material
Deer Mouse Peromyscus maniculatus	variety of habitats used; abundant in early successional stages	primarily a seed eater; also fruits, leaves, insects, fungi	in rotting logs, burrows, among debris and rocks	home range: in Oregon at high densities---.5 to .6 ha; at low densities 2.8 to 5 ha	raptors, snakes, carnivorous mammals	dry habitat with enough ground debris or vegetation for nesting and shelter
Townsend's Vole Microtus townsendii	a denizen of salt marshes and most moist lowlands and sedge meadows of alluvial type areas; occurs to timberline and above in alpine meadows	feeds on underground rootstocks	subterranean tunnels	unknown	barn and short-eared owls, marsh hawks, foxes	loose, friable soil for tunnelling
Vancouver Island Marmot Marmota vancouverensis	prefer south-facing bowl shaped "lush" forb alpine meadows with rock bluff at top	vegetarian; forb species	burrow system in rocky ground or beneath boulders	home range is approx. 3 ha; males may be territorial	cougars, black bears, golden and bald eagles, red-tailed hawks	low disturbance; south facing sub-alpine meadows with steep talus slopes above
Ermine Mustela erminea	habitat mosaic of mature, dense timber and meadows or open areas	forages in open areas for small mammals principally voles and mice; also snakes and frogs	logs, snags, burrows, under rocks	home range from 10 to 15 ha	large carnivores, coyotes, hawks, marten wolverine; man	logs, stumps, snags or excavated burrows for den sites; forest openings for foraging

APPENDIX 13.3 Species life history by lifeform (continued)

Lifeform 7: Reproduces in burrow underground.
Feeds on the ground or in the water.

SPECIES	HABITAT	FOOD	SHELTER	TERRITORY	PREDATOR	HABITAT REQUIREMENTS
Mink Mustela vison	a variety of habitats adjacent to water; marine intertidal, riparian woodlands and marshes	crustaceans, fish frogs, small mammals	burrows, hollow logs, tree stumps	territorial although home ranges overlap; on Van. Is. coast home range size for males is .72 km of shoreline, for females .41 km	great horned owl, bobcat, red fox, coyote, wolf, black bear; man	suitable burrowing sites; permanent source of water
American Beaver Castor canadensis	deciduous tree or shrub communities, either edaphic climax or subclimax, on alluvial soil or hydric shorelines	bark and cambium of aspen, cottonwood alder, birch, willow	bank burrows, dam site, water	territorial; home range in Mackenzie Delta as large as 2 km^2	wolf, river otter, bear, wolverine fisher, lynx, coyote; man	sufficient amount of slow-flowing or standing permanent water adjacent to deciduous food species
River Otter Lutra canadensis	shores of deep, clear water bodies--lakes, rivers, streams, large marshes; on coast, prefers marine environment with a fresh water pond or stream association	fish, crusteceans, amphibians, beaver, birds	bank burrows, hollow logs, water	home range (Sweden) is 7 km for female and cub; 15 km for male	few; wolves and coyotes when travelling over land; man	large permanent water body; hollow logs, excavated burrows or cavities for den sites
American Water Shrew Sorex palustris	prefers area along swift, cold mountain streams with protected bank and ground cover in dense climax coniferous forests; 0-2000 m	primarily aquatic; larvae of stoneflies, caddisflies and mayflies; also tadpoles, fish eggs, other aquatic invertebrates and fish	crevices, over hanging ledges, debris, tunnel system	aggressive beheviour but not territorial; home range information unknown	carnivorous mammals	cold, clear, fast-moving streams with protective shoreline cover and friable soil

APPENDIX 13.3 Species life history by lifeform (continued)

Movement and Habitat Use

	Diurnal	Nocturnal	Shelter			Hibernation		Migrate[1]
			Day	Night	Nursery	Duration	Location	
Vagrant Shrew	x	x	---------- ground debris ----------					No
Dusky Shrew	x	x	---------- ground debris ----------					No
American Water Shrew	x	x	---------- ground debris ----------					No
Little Brown Bat		x	buildings	?	warm dark retreats; attics, buildings	Nov-May	cave, mineshaft	No
Yuma Bat		x	buildings	buildings	mines, caves, buildings, under bridges	Nov-May	?	Yes[2]
Keen's Bat		x	loose bark, trees, bush, rock crannies	caves	under bark, buildings	Oct-May	cave	Yes
Long-eared Bat		x	loose bark, man-made structures	?	loose bark, buildings	Yes	cave, mineshaft	Yes[2]
Long-legged Bat		x	?	caves, cliff faces, mines	trees under loose bark	Yes	?	Yes[2]
California Bat		x	buildings, mines caves, cavities, loose bark	man-made structures, mines, caves	rock crevices, loose bark, bldg	Yes	cave	No
Silver-haired Bat		x	under loose bark, bulky bird's nests	?	?	Yes	under bark, cavities	No
Townsend's Big-eared Bat		x	natural crevices, steeples, caves	caves, buildings	natural crevices, buildings	Oct-May	cave	?
Big Brown Bat		x	hollow trees, buildings	buildings	?	Nov-April	cave, buildings	No

APPENDIX 13.3 Species life history by lifeform (concluded)

Movement and Habitat Use

	Diurnal	Nocturnal	Shelter			Hibernation		Migrate[1]
			Day	Night	Nursery	Duration	Location	
Hoary Bat		x	among tree foliage	?	?	Sept-April	trees	Yes
Vancouver Island Marmot	x		burrows beneath rock piles			Sept-April	burrows	No
Red Squirrel	x		tree cavities, tree limbs, underground tunnel system			Yes	tunnels, excavated under stumps	No
American Beaver	x	x	bank burrow, constructed lodge					No
Deer Mouse		x	grass clumps, under debris, tree cavities, abandoned dens					No
Townsend's Vole		x	surface and subterranean tunnel system					No
Wolf	x	x	hollow in stumps and under logs					No
American Black Bear	x	x			caves, stumps, burrows	Nov-April	cave, stumps, burrows, snags	No
Raccoon		x	cavities, caves, burrows, culverts, barrels					No
American Marten	x	x	hollow logs, cavities in rock piles					No
Ermine	x	x	abandoned burrows, hollow logs					No
American Mink		x	abandoned dens, beaver lodges, stumps, hollow logs					No
Wolverine	x	x						No
River Otter		x	abandoned beaver or muskrat bank burrows, hollow logs					No
Cougar	x	x	trees		caves, hollows among rock piles			No

[1] off Vancouver Island
[2] some individuals may overwinter (Cowan 1942)

APPENDIX 13.4 Species vs habitat component

Format and much of the information presented is from the work by Thomas (1979). Refinements to this information were made using additional literature as presented in the text.

	Rivers	Streams	Lakes	Sloughs	Reservoirs	Ponds	Intermitten Ponds	Marshes: Rush/cattail	Marshes: Sedge	Marshes: Dec. Vegetation	Standing or Slowmoving water	Fast run. water	Beaches	Estuaries	Edges: Grass-shrub	Edges: Shrub-forest	Edges: Grass-forest	Snags	Logs	Burrows	Cliff/rimrock	Talus	Caves
Vagrant Shrew	X	X	X	X	X	X	X		X	X					X	X	X		X	X			
Dusky Shrew	X	X	X	X	X	X	X		X	X					X	X	X		X	X			
American Water Shrew	X	X	X		X						F	F				X	X	R					
Little Brown Bat	F	F	F	F	F	F	F	F	F	F	F					X	X	R			X	F	H
Yuma Bat	F	F	F	F	F	F	F	F	F	F	F					X	X	R			X	F	H
Keen's Bat	F	F	F	F	F	F	F	F	F	F	F					X	X	R*			S		H
Long-eared Bat	F	F	F	F	F	F	F	F	F	F								R*			X		
Long-legged Bat	F	F	F	F	F	F	F	F	F	F	F							R			S		
California Bat	F	F	F	F	F	F	F	F	F	F								R*			X		H[1]
Silver-haired Bat	F	F	F	F	F	F	F	F	F	F	F							R[2]				H	
Townsend's Big-eared Bat	F	F	F	F	F	F	F	F	F	F											X		H
Big Brown Bat	F	F	F	F	F	F	F	F	F	F								R*			X	F	R
Hoary Bat	F	F	F	F	F					F						F	F	S					
Vancouver Island Marmot																X				R	X	X	
Red Squirrel	X	X														X		X	X	X			
American Beaver	X	X	X	X	X					X	X	X							F	R			
Deer Mouse	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X
Townsend's Vole	X	X	X	X	X	X	X		X						X		X						
Wolf	F	F	F	F	F	F	F	F	F	F					F	F	F		R	R			
American Black Bear	X	X	F	X	F	F	F	F	F	F					F	F			F	R	F	F	R
Raccoon	X	X	X	X	X	F	F	F	F	X			F	F	F	F	F	R	R				R
American Marten																		R	F	S	F	F	R
Ermine	X	X	X	X	F	F	F			F					F	F		R	X	X	F	F	R
American Mink	X	X	X	X	X	F	F	X	X	X			F	F					X	X			
Wolverine	F	F	F		F	F	F	F	F	F										R	X	F	R
River Otter	X	X	X	X	X	F	F	F	F	X				F						R			
Cougar	F	F	F	F	F	F	F			F						F	F		R		X		

Key: F - feed
R - reproduction
X - both feed and reproduce
H - hibernacula
S - shelter
* - also roost
1 - also used for reproduction and night roost
2 - also used as roost and hibernacula

APPENDIX 13.5 Species vs successional stage

Format and much of the information presented is from Thomas (1979). Refinements to this information were made using additional literature as presented in the text.

	Grass-Forb	Shrub-Seedling 0-10 yr	Pole-Sapling 11-39 yr	Young 40-79 yr	Mature 80-159 yr	Old Growth 160 + yr
Vagrant Shrew	X	X	X	X	X	X
Dusky Shrew	X	X	X	X	X	X
American Water Shrew	X	X	X	X	X	X
Little Brown Bat	F	F			X	X
Yuma Bat	F	F			X	X
Keen's Bat		F	F	F	X	X
Long-eared Bat	F	F	F	F	X	X
Long-legged Bat	F	F	F	F	X	X
California Bat	F	F			X	X
Silver-haired Bat	F	F	F	F	X	X
Townsend's Big-eared Bat	F	F	F	F	F	F
Big Brown Bat	F	F	F	F	X	X
Hoary Bat	F	F	F	F	F	F
Vancouver Island Marmot	X					
Red Squirrel			X	X	X	X
American Beaver		X	X	X	X	X
Deer Mouse	X	X	X	X	X	X
Townsend's Vole	X	X				
Wolf	F	F	F	F	X	X
American Black Bear	F	F	F	F	X	X
Raccoon	F	F			X	X
American Marten			F	F	X	X
Ermine		F	X	X	X	X
American Mink	X	X	X	X	X	X
Wolverine	F	X	X	X	X	X
River Otter	X	X	X	X	X	X
Cougar	F	F	F	F	X	X

Key: F - feed
R - reproduction
X - feeding and reproduction

APPENDIX 13.6 Effects of intensive forest management

The information presented is the combined result of specific information about the effects of intensive forest practices on mammals from the cited literature and the hypothetical effects based on the species information available.

Criteria used to evaluate the effects:

Clearcutting
- A. on site: removal of canopy cover; produces drier site; increases debris; hydrology changes
- B. off site: effect on water resources

Burning
- A. removal of debris and organic horizons; xeric site produced
- B. long term: earlier successional understory species present

Scarification
- removal of debris and organic horizons; xeric site produced

Planting
- A. immediate: as a food source
- B. long term: advances forest stand succession

Cleaning - mechanical
- A. immediate: removal of understory canopy; ground debris inceases
- B. long term: advances forest stand succession

Cleaning - chemical
- A. immediate: direct toxicity of herbicide to species; effect on water supply; effect on species habitat or habitat of their prey
- B. long term: advances forest stand succession

Pre-commercial thinning (cut trees remain)
- A. immediate: opening of forest canopy; increase in ground debris; removal of understory cover
- B. long term: advances forest stand succession

Fertilization
- A. immediate: direct toxicity to species; effect on water supply
- B. long term: advances forest stand succession

Commercial thinning (removal of trees)
- A. immediate: opening of forest canopy; increases understory cover
- B. long term: advances forest stand succession

APPENDIX 13.6 Effects of intensive forest management (continued)

	Lifeform	Clearcutting on site		Clearcutting off site		Burning min debris, xerfc	Burning early succ	Scarification	Planting food	Planting adv succ	Mech clean min debris	Mech clean adv succ	Chem clean toxicity	Chem clean adv succ	Precom Thin op canopy, inc debris		Precom Thin adv succ		Fertilization toxicity	Fertilization adv succ	Com Thin op canopy, inc understory		Com Thin adv succ	
		A		B		A	B		A	B	A	B	A	B	A		B		A	B	A		B	
Townsend's Big-eared Bat	1	+		o		+	o	o	o	-	o	o	-	o	o		o		o	o	o		o	
Wolverine	2	-		o		-	o	-	o	+	o	+	o	+	o		+		o	+	o		+	
Red squirrel	3	-		o		-	o	-	o	+	o	+	o	+	o		+		o	+	o		+	
Hoary Bat	4	-		o		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Little Brown Bat	5	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Yuma Bat	5	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Keen's Bat	5	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Long-eared Bat	5	-		o		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Long-legged Bat	5	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
California Bat	5	-		o		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Silver-haired Bat	5	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Big Brown Bat	5	-		o		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
Wolf	5	+		o		-	+	o	+	+	o	+	o	+	o		+		o	+	o		+	
American Black Bear	5	+		o		-	-	-	o	+	o	+	o	+	o		+		o	+	o		+	
Raccoon	5	-		-		-	-	-	o	+	o	+	o	+	o		+		o	+	o		+	
American Marten	5	-		o		-	-	-	o	+	+	+	+	+	+		+		o	+	o		+	
Cougar	5	+		o		-	+	o	+	+	o	+	o	+	o		+		o	+	o		+	
Vagrant Shrew	6	-		o		-	o	-	o	+	o	+	o	+	o		+		o	+	o		+	
Dusky Shrew	6	-		o		-	o	-	o	+	o	+	o	+	o		+		o	+	o		+	
Deer Mouse	6	+		o		+	o	+	o	-	o	-	o	-	o		-		o	-	o		-	
Townsend's Vole	6	-		-		-	+	-	o	o	-	o	o	o	o		o		o	o	o		o	
Vancouver Island Marmot	6	-		o		-	o	-	+	+	o	+	o	+	o		+		o	+	o		+	
Ermine	6	+		o		-	o	-	o	+	+	+	o	+	+		+		o	+	+		+	
American Mink	7	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
American Beaver	7	+		-		+	o	-	-	+	o	+	o	+	o		+		o	+	o		+	
River Otter	7	o		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	
American Water Shrew	7	-		-		-	o	-	o	+	o	+	-	+	o		+		o	+	o		+	

Key: + positive effect
- negative effect
o no appreciable effect

APPENDIX 13.7 Personnel communications

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